

REMARKS/ARGUMENTS

Claim 1 has been amended to specify the H₂S and mercaptan-containing gas stream is a gaseous hydrocarbon stream; to recite the conditions, including temperature and pressure, in the separate H₂S and mercaptan removal zones; and to recite the low levels of H₂S and mercaptans in the treated gas stream. Support for the amendments is found on page 12 of the specification, lines 12-15; page 7, lines 3-9; page 8, lines 3-8; page 9, lines 15-24 and page 4, lines 12-16.

Claim 2 has been amended to recite the relationship between the pH levels in the respective removal zones. Support for this amendment is found on page 9, lines 19-21.

Claims 3, 4 and 5 have been amended to recite preferred pH ranges in the respective removal zones and in the oxidation reactor. Support for these amendments is found on page 9, lines 15-24, and on page 10, lines 25-29.

Claims 6, 7 and 8 have been amended to recite preferred concentrations of H₂S and/or mercaptans in various gas streams, support for which is found on page 6, line 2 and lines 26-30, and page 9, lines 1-4.

Claim 9 has been amended to further describe the gas scrubbers. Support for the amendment is found on page 4, lines 20-30.

New claim 11 recites preferred concentration ranges for H₂S and mercaptans in the mercaptan-depleted gas stream. Support for the new claim is found on page 8, lines 27-33 and page 9, lines 1-3.

Claim Rejections - 35 U.S.C. § 103

The rejection of claims 1-10 under 35 U.S.C. § 103 (a) as being unpatentable over Buisman (US 5,354,545) in view of Fernandez de la Vega et al (US 5,659,109), evidenced by LaFoy (US 4,562,300) is respectfully traversed.

The present invention provides an improved five step process for the removal of H₂S and mercaptans from a gaseous hydrocarbon stream, such as natural gas or refinery streams, to very low levels, i.e., H₂S levels less than 10 ppmv (e.g., 0.02 to 3.5 ppmv) and mercaptan levels less than 6 ppmv (e.g., less than 4 ppmv or even less than 2 ppmv). This is accomplished by contacting the gaseous hydrocarbon stream with a buffered aqueous alkaline washing liquid under certain conditions of temperature and pressure in two separate removal zones, a H₂S removal zone and a mercaptan removal zone. The requirement for separate H₂S and mercaptan

removal zones, the specific conditions in the respective zones (including temperature, pressure and buffering of the alkaline washing liquid) and the low levels of H₂S and mercaptans in the treated gas, i.e., less than 10 ppmv H₂S and less than 6 ppmv mercaptans, are all now recited as limitations in the amended claims.

Applicant respectfully submits that the five step process of the invention including separate H₂S and mercaptan removal zones, operated under certain specified conditions to produce a treated gas having the specified low H₂S and mercaptan levels, would not be obvious from the cited references, alone or in combination, for the reasons discussed below.

The Buisman Reference

Buisman discloses a process for removing sulphur compounds from gaseous effluents such as biogas, ventilation air, and combustion gases (abstract and col. 6, lines 39-47). Unlike the presently claimed process which removes H₂S and mercaptans from gaseous hydrocarbon streams in two separate removal zones, Buisman removes H₂S and mercaptans from the gaseous effluent in a single contacting step, i.e., by treatment with a washing liquid in scrubber 2 in Fig. 1. While Buisman teaches that the washing liquid employed in the gas scrubber should be buffered to a pH between 6.0 and 9.0, Buisman does not teach any temperature or pressure ranges for gas scrubber. Thus, in addition to not teaching the use of separate H₂S and mercaptan removal zones (which is acknowledged in the subject Office action), Buisman does not teach the temperature and pressure conditions employed in the separate H₂S and mercaptan removal zones of Applicant's process, nor does Buisman's process achieve the extremely low H₂S and mercaptan levels achieved by present process (i.e., less than 10 ppmv H₂S and less than 6 ppmv mercaptans).

In this regard, the Examiner's attention is directed to Table A in col. 6 of Buisman, which shows the purified gas leaving scrubber 2 through line 3 has an H₂S concentration of 150 ppm. This is an order of magnitude higher than the less than 10 ppm H₂S level achieved by Applicant's process. Since the temperature, pressure and buffering conditions in the two removal zones are specifically recited in the present amended claims, as well as the low levels of H₂S and mercaptans achieved by Applicant's process, the present amended claims are believed to be clearly patentable over Buisman for these reasons, as well as the fact that Buisman does not teach performing H₂S and mercaptan removal in separate removal zones.

The Fernandez de la Vega et al Reference (de la Vega)

De la Vega discloses a process for liquefying natural gas containing mercaptans in which the mercaptans are concentrated into a distillate stream by distilling the feed gas stream without any specific pretreatment for mercaptans removal (Abstract).

The process disclosed in de la Vega for removing mercaptans from natural gas is quite dissimilar from the process in Buisman or the Applicant's process, in that de la Vega does not employ a washing liquid in a scrubber to remove mercaptans, but instead removes the mercaptans from the raw natural gas by distillation. The removal of mercaptans from the raw natural gas is accomplished in scrub column 14 in Fig. 1 of de la Vega which is a conventional distillation type column having 5 to 8 or more trays. The mercaptans are removed from scrub column 14 as a mercaptan-rich bottom stream comprising much of the C₂ and heavier components via line 28 (See col. 3, lines 29-55).

An understanding of the mercaptan removal process disclosed in de la Vega is essential to put into context the portion of de la Vega cited in the subject Office action. The cited portion of de la Vega (col. 1, lines 21-24) reads as follows: "Where high levels of mercaptans are encountered, removal techniques must be used in addition to the treatment process for carbon dioxide and hydrogen sulfide." In the next sentence De la Vega teaches that: "The use of the physical or chemical solvent systems is expensive and complicated from an operational standpoint." (Col. 1, lines 25-26). De la Vega goes on to state "Therefore, a need exists for a method for liquefying raw, mercaptan-containing natural gas which avoids the problems and disadvantages associated with the aforementioned prior art pretreatment methodologies." (Col. 1, lines 37-41).

Thus, when viewed in the proper context, it can be seen that de la Vega does not teach or suggest removing mercaptans from natural gas stream by scrubbing the gas stream with a washing liquid comprising a physical or chemical solvent, such as the carbonate or bicarbonate-containing aqueous washing liquid employed by Buisman et al, or the aqueous alkaline washing liquid employed by Applicant. To the contrary, de la Vega teaches such processes "are expensive and complicated" and therefore mercaptan removal from natural gas should be accomplished by distillation.

Since de la Vega teaches mercaptan removal from natural gas with chemical or physical solvents is expensive and complicated and therefore should be avoided, if one were to modify the process of Buisman by adding an additional mercaptan removal step after the H₂S removal step based on the teachings of de la Vega, that additional step would be the removal of mercaptans by distillation. Thus, a process based on the combined teachings of Buisman and de la Vega would not result in Applicant's process which removes H₂S and mercaptans from gaseous hydrocarbons

using a chemical solvent (a buffered alkaline aqueous wash liquid) in both removal zones. De la Vega actually teaches away from this.

For the same reason, the combined teachings of Buisman and de la Vega would not result in an “identical apparatus” as stated on page 4 of the subject Office. As discussed above, scrub column 14 in Fig. 1 of de la Vega is a distillation column in which mercaptans are separated from the lighter fractions by distillation and are removed from column 14 as a mercaptan-rich bottom stream through line 28. Thus, the combined Buisman/de la Vega apparatus would not have two gas scrubbers for contacting the H₂S and mercaptan-containing gas stream with an alkaline aqueous washing liquid as recited in amended claim 9.

Since the combined teachings of Buisman and de la Vega would not result in the same process as Applicant’s process, or in an apparatus identical to Applicant’s apparatus, there is no reasonable basis to conclude the combined process and apparatus of Buisman and de la Vega would produce a mercaptan-depleted gas stream having H₂S levels less than 10 ppmv and mercaptan levels less than 6 ppmv as recited in present claims. The purified gas in Buisman has an H₂S concentration of 150 ppm as discussed above. De la Vega does not disclose the H₂S concentration of the liquefied natural gas produced by the patented process. De la Vega does teach that the patented process can be operated to meet the LNG specification of a mercaptan concentration of 8 ppm (col. 6, lines 43-48).

The LaFoy Reference

LaFoy discloses an improved process for removing mercaptans from a hydrocarbon stream such as hydrocarbon distillates and sour gasoline by contacting the hydrocarbon stream with an alkaline solution in which mercaptides are soluble (col. 1, lines 4-11 and col. 2, lines 28-33). The alkaline solution is regenerated by oxidizing the mercaptides to disulfides using a catalyst, which results in a regenerated alkaline solution which still contains about 25 percent of the original sulphur compounds (col. 1, lines 13-27). The improvement in LaFoy comprises contacting the regenerated alkaline solution containing the disulfides with a previously treated hydrocarbon stream to remove disulfides from the caustic (col. 1, lines 47-51).

LaFoy is apparently being cited for its teaching of a mercaptan extraction process using an alkaline solution for the removal of mercaptans. Beyond this general teaching, LaFoy is of little relevance, since LaFoy does not teach removing H₂S and mercaptans in separate removal zones, appears to employ an unbuffered caustic solution for mercaptan removal, employs oxidation in the presence of a catalyst to regenerate the alkaline solution, and does not teach obtaining a treated gaseous hydrocarbon having the low levels of H₂S and mercaptans recited in the amended claims.

Summary

Applicant respectfully submits that the present claims, as amended, are patentable over the cited references in that Buisman does not teach performing H₂S and mercaptan removal in separate removal zones; does not teach the specific conditions, including temperature and pressure, in the separate H₂S and mercaptan removal zones; and does not teach or achieve the low levels of H₂S and mercaptan removal recited in the present claims. The purified gas in Buisman actually has an order of magnitude higher H₂S level (e.g., 150 ppm)

While de la Vega teaches that when high levels of mercaptans are encountered in natural gas, the mercaptans should be removed using special techniques, the special technique specifically taught by de la Vega for removal of mercaptans from natural gas is distillation. Moreover, de la Vega teaches away from using chemical or physical solvents for mercaptan removal in natural gas, since physical and chemical solvent systems are said to be expensive and complicated. Thus, the combined teachings of Buisman and de la Vega would not result in Applicant's process, nor produce an identical apparatus, since Applicant employs a chemical solvent, i.e., a buffered aqueous alkaline washing liquid, for mercaptan removal as well as for H₂S removal. Applicant's apparatus includes two scrubbers wherein the H₂S and mercaptan-containing gas is contacted with the buffered aqueous alkaline washing liquid.

Lafoy teaches mercaptans can be removed from hydrocarbon streams such as sour gasoline with the use of an alkaline solution, but otherwise adds nothing to overcome the deficiencies in Buisman and de la Vega discussed above.

Conclusion

For all of the above reasons, claims 1-10 and new claim 11 are believed to be patentable over the cited references and in condition for allowance, which action is respectfully requested.

Respectfully submitted,

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